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ORIGIN OF THE PRAIRIES.

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I PROPOSE to offer some observations on the Origin of the Prairies, though it may seem like presumption in me to attempt the discussion of a subject which that greatest of nature's students, the immortal Humboldt, seems studiously to have avoided. He describes to us all the prairies of the world, a great portion of which he had personally examined. He gives us their area, their geography, their topography, their surrounding, their components and their products, but gives us no word of suggestion or explanation why they are destitute of trees, when surrounded and interspersed everywhere by forests. This, indeed, seems very remarkable in one who was, perhaps, the most extraordinary man that ever lived for observing, studying and explaining every interesting phenomenon in nature. Why has not he, the most able of all men to discuss it, favored us with his views on this subject? We are hardly at liberty to suppose it was a mere oversight, and are loth to believe that he considered the inquiry of so little importance as to be unworthy of his notice. This would be too severe a reflection upon all those who have since considered the inquiry worthy of the most serious consideration. Since his time it has been the subject of much study and of many and conflicting theories. Although he, whom of all others we should listen to with the greatest interest, in answer to this inquiry, has, so far

as I know, not chosen to enlighten us with his views, yet the origin of the Prairies is a theme which has commanded the attention of many, both of those whose eminent attainments entitle them to the appellation of learned, and those who dwell upon them but make no pretensions to such distinction. By the former, theories have been advanced and elaborated and placed on record, some of which are quite inconsistent with others, so that all of them, at least, cannot be true; and probably we should not be very far out of the way should we conclude that some errors have crept into all, and also that none of them are entirely destitute of truth. Indeed, we are sometimes inclined to the belief that each one has written as if called upon to advance something entirely original, and this may have led some to the very borders of absurdity, and would almost induce the belief that their authors had never seen a prairie. Upon this, as upon all other subjects where we must depend upon evidence to lead us to correct conclusions, it is indispensable that we proceed upon *facts* and, so far as possible, *all* the facts which can enlighten our judgments upon the subject. The very moment we proceed upon assumed facts which in truth do not exist, then most likely the first step will be error, and so we shall be led by false lights to the very end, and it will be remarkable if our conclusions are not erroneous.

All men, and especially the learned, are, perhaps, too prone to theorizing, and such is the weakness of human nature that when a theory is once formed and announced, it is our child, our offspring, our fondling, and we seem to feel the obligation of a parent to ever after maintain and support it. Though, as it grows up, it may become deformed and ugly, and unworthy of our further care, it requires the stoicism of the Roman father to dis-

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card it and order its execution. All manner of violence is done to facts to win support and sustenance for the bantling, and every grain of proof in its defense is made to weigh a pound.

Each of the theories which have been advanced on this subject undoubtedly has some facts for its support, and possibly may account for the formation of some prairies; but neither is capable of accounting for all prairies. Hence I conclude that various causes have contributed to the formation of the prairies. It may be that some prairies have been formed by processes entirely different from processes which have formed others.

But, first of all, in the discussion of this subject, and so it is of all others, it is necessary to have a distinct understanding of the subject to be discussed. We must know precisely what particular facts are to be explained, what phenomena are to be accounted for. There are two distinct elements to be considered in the discussion of this subject. The one is the deposition of the soils and the configuration of the surfaces of the prairies; and the other is the absence of arborescent vegetation upon them, in what may be termed their natural state, while they are clothed with a rich coat of herbaceous vegetation. So it will be seen that I only propose to discuss what may be called the fertile prairies, laying entirely out of view those arid deserts formed in many portions of the globe where rains are so seldom that few varieties of the vegetable kingdom can exist without artificial irrigation.

My attention has been lately recalled to this subject by the re-perusal of a paper prepared by Professor Leo Lasquereux for the Report of the Geological Survey of Illinois, and published in that Report, Vol. 1, page 238. Hence has it become the property of our State, and invites the criticism of all her citizens, thousands of whom

have devoted much study to the subject, with better means of understanding it than is possible to one whose observations are confined to a mere superficial examination of them, as was evidently the case with the learned author of this paper, as I think I shall show before I conclude, although I attempt it with the greatest deference and respect for such high authority.

The theory of the learned Professor may be briefly stated thus: Prairies were originally formed in the shallow margins of agitated waters, either lakes or running streams. By the agitation of the waters of lakes drifting material is thrown up at a greater or less distance from the shores, forming dams or dykes, which serve to cut off shallow sections of water from the main body. These shallow ponds of water, being protected from the agitations of the main body, become the habitat of aquatic plants, which in successive crops decay and are reproduced, thus contributing to fill up the shallow pools, which end is also promoted by atmospheric deposits and the growth and decay of animal aquatic life, until finally the bottom of the pent up waters is raised above the surface, and a prairie is formed. The same process is repeated along the margins of rivers, where similar deposits are made in the still waters on either side of the active current, which cuts off sections of shallow water into quiet ponds along the river bottoms, which become filled up and are converted into prairies in the same way. The paper says: "This peculiarity of formation explains, first, the peculiar nature of the soil of the prairies. It is neither peat nor humus, but a black, soft mould, impregnated with a large proportion of ulmic acid, produced by the slow decomposition, mostly under water, of aquatic plants, and thus partaking as much of the nature of peat as true humus. In all the depressions of the prairies, where water is per-

manent and unmixed with mineral matter, the ground is true peat. It is easy to understand why trees cannot grow on such kind of ground."

Now, the first criticism which the consideration of this theory invites is, that it assumes that all prairie soils are of the same character and constituents, and hence the conclusion that they were all formed in the same way and are alike unfitted to the growth of trees.

All familiar with the prairies, even the most superficial observers, know that this is not the case. There is almost, if not quite, as great a variety of prairie soils as of woodland soils. Scarcely one acre in the thousand of the great prairies of Illinois and Iowa would be recognised by this description. Peat bogs, as described by our author, are frequently met with, and sometimes bordering them the kind of soil he describes where ponds have been filled up and converted into marshes, and these, by a continuance of the same process, have finally become dry prairies; but a very large proportion of our dry prairies abound in true humus, while many are scantily furnished with vegetable matter. Such is the character of all our sandy prairies, a striking example of which is found near Pekin, in this State, stretching clear away to the banks of the Mackinaw, and even beyond it. Of the same character, also, are the prairies at Peoria, at Chillicothe, at Lacon, at Hennepin, and at Henry, and twenty others which I could name in Illinois. This soil is as permeable to the atmosphere, is as accessible to oxygen as any soil capable of sustaining vegetable life.

Surely these prairies are not treeless because the seeds of arborescent plants deposited on or in them are not accessible to the oxygen necessary to their development, which is, in fact, the only reason which the writer assigns for the absence of trees on the prairies. He says, imme-

diately after my last quotation: "The germination of seeds of arborescent plants needs the free access of oxygen for its developments, and the trees, especially in their youth, absorb by their roots a great amount of air, and demand a solid point of attachment to fix themselves. Moreover, the acid of this, by its particularly antiseptic properties, promotes the vegetation of a peculiar group of plants principally herbaceous." The truth is, all the vegetation found on the high prairies requires the accessibility of oxygen to its roots for its proper nutrition—nay, its vitality. Transfer the grasses on the rolling prairies into the swamps, or even the humid soil of the swales, and they will die as if burned with fire. The vegetation upon the prairies changes as they become dryer, no matter from what cause. Artificial draining produces this effect with appreciable rapidity. This, no doubt, is not entirely owing to the absence of stagnant water in the soil, but also to the absence of certain salts, which have been washed out by affording a passage to the water percolating through the soil. Although I cannot assert from actual analysis that this change takes place in the constituents of the soil by the process of draining, I think it is not a hazardous conjecture to suppose so, nor is it more unreasonable to suppose that the pores left vacant by draining off the water are directly filled by air, and so is the soil at once supplied with an abundance of oxygen necessary to the vitality of a new class of vegetation, which succeeds the old. The difference in the vegetation found on the different prairies, or on different parts of the same prairie, testifies to the different constituents in their soils. So soon as the soil is raised above the water, atmospheric air will penetrate it, more and more, in almost the exact ratio that it becomes drier. Both mechanical and chemical changes are thence continually going on, and so

are the constituents of the soil continually changing, and so does the character of the vegetation found upon them change, so that the soil will always be covered with some class of vegetation, to which it is adapted. But it does not follow that all the kinds of vegetation which the soil is adapted to sustain, will be found there. Indeed, but a very few may be looked for. The selection of those that are found and the exclusion of those absent, are determined by causes quite independent of the constituents of the soil. They are dependent upon accidental causes.

The theory under consideration also assumes that the subsoil of the prairies is uniformly clay. A more intimate acquaintance with the prairies would have corrected this misapprehension. The super-soil of the prairies sometimes rests upon gravel and sometimes upon rock, and sometimes this gravel subsoil, at a greater or less depth, rests upon either a stratum of clay or upon rock. An example of the former may be found on the east side of the Du Page river, above Plainfield, in this State,—where we have the exceptional case of the entire absence of timber along the borders of a considerable river for many miles,—and in many places along the Fox river. Also, near Lisbon and at Joliet, we find the soil resting upon rock, with no clay interposed. Near Lisbon, particularly, this is found on the high, rolling prairie, far away from the river bottoms and from timber. I might cite many similar examples, but it is unnecessary. The vegetation covering all these, which is not controlled by the humidity of the soil, is substantially the same, but neither the surface or the subsoil has in general anything to do with absence of arborescent vegetation.

That the prairies—that is, the land itself—have been formed under water, except the very limited portion of the surface which has been added from decomposed ani-

mal and vegetable matter since their emergence, will not be questioned by any one of the least observation; but that is not the main question involved in the present inquiry. Why are they not covered with forests? It is the cause of this feature which Prof. Lesquereaux undertakes to explain. His theory of the territorial formation is introduced solely for the purpose of explaining this phenomenon, and which it fails to explain, at least to my satisfaction.

If the Grand Prairie of Illinois was formed under water, from which it emerged by a slow process of elevation or by a subsidence of the waters, a theory to which I am prepared to assent, or if it was formed piecemeal by having one section of shallow water, and then another, cut off from the main body by the accumulation of deposits by the agitated waters, as described in the theory under consideration, then the lands now covered by the immense forests lying north and east of us, in Wisconsin, Michigan, Indiana and Ohio, and of the same general altitude, were formed in the same way; and if this process of formation is the true cause why trees are not found on our prairies, then the same cause should have produced the same effect there. But more, if this theory be correct, then the latest formations of land should be nearest the great bodies of water from which they have been detached, and less congenial to the growth of trees, and we should expect to find the forests most remote from the waters. Now the very reverse of this is found, in fact, to be the case. At one single point alone does the Grand Prairie abut on Lake Michigan, and that for the short distance of four miles south of the mouth of the Chicago river. The great forests of Indiana are in the north part of that State, and we must go south of those forests to find her large and luxuriant prairies. In Northwestern

Indiana we find those large swamps, which may have been cut off from the waters of the lakes in the manner supposed by Prof. Lesquereaux, and which are now in the process of being filled up; but it is a remarkable and interesting fact, that wherever a point, no matter how small, in any of these great marshes, has been raised above high water, it is covered with trees. No traveler can pass over the Pittsburg, Fort Wayne and Chicago Railroad, for instance, without having his attention arrested by the innumerable islands, all covered with trees, rising everywhere out of this great marsh, all with surfaces but a very few feet above the water. If he has ever passed down the St. Lawrence, among the Thousand Islands, he is at once reminded of the fact by the similarity of the relative location, size and number of the islands. I have in vain sought among these marshes for a dry place devoid of trees, except on the dykes themselves, portions of which may be found quite destitute of any vegetation, where the dry sand will afford sustenance to none.

That these marshes once formed a portion of the body of the lake, and have been cut off from it by dykes thrown up by agitated waters, may be true. Indeed, these dykes are as readily traced to-day as are the shores of the lake or the borders of the marshes themselves; but they are not uniformly overgrown with trees, as is supposed by the author of the theory under consideration. More than thirty-five years ago I examined one of the most remarkable of these ridges, south of where the village of Thornton now stands. It is composed principally of compact gravels, as straight as possible, nearly north and south; I should think, perhaps three hundred feet wide, and elevated, probably, ten feet above the marshes on each side. It is as regular in its grade as if thrown up by the hand of man, under the direction of a skillful

engineer, and constitutes the most beautiful natural drive I ever saw, and, I understand, is now used as a public road. Not a tree was standing on it, nor the evidence that there had ever been one. The soil was light, but sufficient to sustain the pine or the black oak.

Although it is reasonable to suppose that this dyke cut off the waters to the west long before the waters to the east of it were separated from the lake by a similar process, yet the marsh on the west was not, and I venture to say is not now elevated appreciably more than that on the east. This may serve to teach us how extremely slow is the filling up process of these marshes, even after they have been elevated so as to become passable to animals, and are annually covered with a heavy growth of grass—so slow, indeed, that it is inappreciable from one generation of men to another. I accept this as an evidence of the formation of some prairies in the manner supposed by our author, but not as a reason why they are destitute of trees. It seems to me that he does not sufficiently appreciate the effect of the chemical and mechanical action of the elements upon all things above the waters even in a short period, as reckoned by geological time, in which the life of man is so short as to be hardly an appreciable moment, and the entire historic period is scarcely long enough for a single breath. Although, geologically speaking, we can consider this a new country, yet time enough has elapsed since these high prairies were first elevated, or rather, I will say, were last elevated above the waters, to add to them something, at least, from animal and vegetable deposits and particles floating in the atmosphere, though slow indeed has been and will be this accumulation upon the surface, accelerated or retarded by human industry where civilization directs its energies.

Through the changes of accumulating ages, the soils of

our prairies and woodlands have no doubt, at different times, been adapted to the healthy growth of almost every variety of vegetation of the temperate zone, both herbaceous and arborescent, nor do I think it unreasonable to suppose that not only our present prairies, but the great forest land covering the plains which spread away clear to the foot of the mountains east of us, may have been many times clothed with heavy forests, and these again denuded to naked prairies. It is a familiar fact, that places have been found covered with what appeared a primeval forest of hard wood, showing abundant remains of a growth of pine, which must once have occupied the same place. No fact is better settled in agricultural science, than that any particular crop of vegetation, if long continued, will in time exhaust the element necessary to its vigorous growth, when, if vegetation requiring a different element be substituted, it will grow with peculiar luxuriance. Hence the necessity for rotation of crops, which has been thus enforced by the laws of nature herself long before man appreciated its utility or adopted it in practice.

When the vegetation is not taken from the ground, but is allowed to return to it, the process of exhaustion is, no doubt, retarded to a certain extent, but is not entirely arrested, and hence we see this rotation of crops wrought out by the hand of nature itself, although at longer intervals than is required for the husbandman.

I entirely concur in the popular opinion, that among the most important of the causes which have produced this interesting result is fire, while the exhaustion and replenishing the soil with particular elements have, no doubt, had their influence.

The opinions of the first settlers on the prairies, who are often good observers of many phenomena, are entitled to respect, and, so far as I am aware, they universally at-

tribute the absence of trees from the prairies to the periodical fires which swept over them, overlooking, no doubt, many minor causes. The hard, impenetrable character of the sward, formed by most of the herbaceous vegetation of the prairies, forms a serious impediment to the germination of seeds of trees, when, by accident, they fall upon it. It is not the composition of the soil that prevents the germination of this class of seeds, but whatever difficulty is experienced in this regard arises from the mechanical cause above suggested. The herbaceous vegetation which covers the prairies is furnished with an immense number of very strong roots,—far more so than any of the tame or cultivated grasses. In general, these form a complete mat on the surface and penetrate to a great depth. They are often met with of a considerable size at a depth of six or eight feet. The extraordinary system of capillary roots with which they are furnished enables them to remain green and vigorous during the long drouths, which much more frequently occur on the prairies than in the timbered lands and in mountainous countries, during which the cultivated grasses, and even the clover, with its long tap-roots, greatly suffer. These long drouths, no doubt, also exert their influence to prevent the germination of arborescent seeds on the prairies, or to destroy the young plants, or, at least, to prepare them for certain destruction when the autumnal fires shall sweep over them.

It is a familiar fact to all careful observers that fire is much more destructive to the vitality of arborescent than to herbaceous plants, *ceteris paribus*. A fire that will destroy the last vestige of life in a tree of considerable size will leave the roots of the grasses surrounding it unharmed, from which will spring a more luxuriant growth the succeeding season. Indeed, it is a most interesting

fact, familiar to all the early settlers, who depended upon the prairie grasses for pasturage and for hay, that a much more luxuriant growth is produced on the prairies where the old grass is burned off than where it is allowed to remain and decay upon the ground. I have in person often made careful observations on this subject, and uniformly with the same result. The farmer does not burn off the old grass in the fall solely that it may not obstruct the scythe when mowing the next year's crop, but the most casual observation will show one that the actual growth of grass is ordinarily at least one-third greater where the old grass has been burned off in the fall. I shall not stop now to explain why this is so, although I think it susceptible of a most satisfactory solution, but at present content myself with the fact that the roots of the prairie herbage are not injured by a very considerable degree of heat where even large trees would be liable to be destroyed. What, then, must be the fate of the tree of but a few months' growth? Utter annihilation seems absolutely inevitable. So long as the prairies are subject to the annual conflagrations, to which they are so much exposed in a state of nature, there is a manifest cause why trees get a lodgement on them with so much difficulty.

While I will make no question with Prof. Lesquereaux as to the process by which the marshes or swamps in the vicinity of some of our lakes and rivers have been formed, or the reasons why trees do not grow in them, conceding that perpetual stagnant water is destructive of arboraceous vitality, the error, I conceive, consists in carrying the proposition too far, and applying it where the existing conditions render it inapplicable,—in extending it from the marshes perpetually covered with water to the high, rolling prairies, where none of the conditions exist which prevent the growth of trees in the stagnant waters of the

marshes. The cause of the absence of trees on the upland prairies is the problem most important to the agricultural interests of our State, and it is the inquiry which alone I propose to consider, but I cannot resist the remark that wherever we do find timber throughout this broad field of prairie, it is always in or near the humid portions of it,—as along the margins of streams, or upon or near the springey uplands. Many most luxuriant groves are found on the highest portions of the uplands, but always in the neighborhood of water. For a remarkable example, I may refer to that great chain of groves, extending from and including the Au Sable Grove on the east and Holderman's Grove on the west, in Kendall county, occupying the high divide between the waters of the Illinois and the Fox rivers. In and around all the groves flowing springs abound, and some of them are separated by marshes, to the very borders of which the great trees approach, as if the forest were ready to seize upon each yard of ground as soon as it is elevated above the swamps. Indeed, all our groves seem to be located where water is so disposed as to protect them, to a greater or less extent, from the prairie fire, although not so situated as to irrigate them. If the head waters of the streams on the prairies are most frequently without timber, so soon as they have attained sufficient volume to impede the progress of the fires, with very few exceptions, we find forests on their borders, becoming broader and more vigorous as the magnitude of the streams increases. It is manifest that lands located on the borders of streams which the fires cannot pass are only exposed to one-half the fires to which they would be exposed but for such protection. This tends to show, at least, that if but one-half the fires that have occurred had been kindled, the arboraceous growth could have withstood their destructive influence, and the whole sur-

face of what is now prairie would be forest. Another confirmatory fact, patent to all observers, is, that the prevailing winds upon the prairies, especially in the autumn, are from the west, and these give direction to the prairie fires. Consequently, the lands on the westerly sides of the streams are the most exposed to the fires, and, as might be expected, we find much the most timber on the easterly sides of the streams.

Another fact, always a subject of remark among the dwellers on the prairies, I regard as conclusive evidence that the prairie soils are peculiarly adapted to the growth of trees is, that wherever the fires have been kept from the groves by the settlers, they have rapidly encroached upon the prairies, unless closely depastured by the farmer's stock or prevented by cultivation. This fact I regard as established by careful observation of more than thirty-five years, during which I have been an interested witness of the settlement of this country,—from the time when a few log cabins, many miles apart, built in the borders of the groves, alone were met with, till now nearly the whole of the great prairies, in our State at least, are brought under cultivation by the industry of the husbandman. Indeed, this is a fact as well recognised by the settlers as that corn will grow upon the prairies when properly cultivated. Ten years ago I heard the observation made, by intelligent and observing men, that within the preceding twenty-five years the area of the timber in the prairie portions of the State had actually doubled by the spontaneous extension of the natural groves. However this may be, certain it is that the encroachments of the timber upon the prairies have been universal and rapid, wherever not impeded by fire or other physical causes, without regard to the constituents of the soil.

The manner and progress of the encroachments are

familiar to all. The hazel is the usual pioneer in these encroachments, though sometimes even this is preceded by the wild apple. No one can at this day travel two hours on any of the railroads through our prairies without passing some grove of timber bordered by considerable belts of hazel, among which, not far from the outer edge, young forest trees will appear, and these will be observed larger and larger as they are farther and farther from the edge of the grass, and are found nearer and nearer the original forest, and this where there has been no cultivation. This is the usual though not universal appearance of the surroundings of the groves at the present day. Sometimes, no doubt, large trees will be found as advance sentinels, standing out quite in the prairie, but how they have been able to maintain their ground there we may not at all times be able to explain. Such instances are rare exceptions. The general rule is, that the hazel is in the advance, and from this we may safely conclude that this shrub can maintain the struggle for life with the prairie grass better than forest trees, while in turn it succumbs to the latter. In the hazel rough the seeds of the trees find an accessible soil, where the young plants are indifferent to or are benefited by the shade. In time they rise above the hazel, and at length grow to sufficient size to constitute a forest, and shade the ground, which destroys the hazel, which was their protecting nurse in infancy. The facts stated, I think, clearly warrant the conclusion drawn.

In the paper under consideration the author, in answer to some, I think, well considered remarks of Prof. Winchell, says: "The second assertion, that *trees will grow on the prairies when introduced or planted*, is certainly true. But we should take care to make a distinction between the results of an artificial process and a natural one.

When trees are planted on the prairie the soil is conveniently prepared. The clayey subsoil mixed with the black mould forms a compound which combines density of certain parts with lightness of others, and contains a great proportion of nutritive elements. If the clay of the subsoil is not too thick to be impermeable to water, and thus to retain it around the roots, this prepared or artificial ground is very appropriate to the growth of trees. But has ever anybody seen oaks or hickories, or any other kind of trees, grow in the prairies from a bushel of acorns or of nuts thrown upon their surface? Why, then, if trees will grow on the prairies, do we not see those isolated and far-between clusters of trees which appear here and there on the borders of ancient lakes cover a wider area and by and by invade the whole prairies? Some of those trees have lived there for ages, their trunks are strong and thick, and their branches, widely expanded, are shaken and their fruits swept away by the impetuosity of the autumnal storms; and, nevertheless, their domain is restricted by the nature of the ground to limits which they have never surpassed."

Now, the observations already stated, and about which I cannot be mistaken, and in support of which thousands of witnesses who have dwelt upon the prairies for many years, and have been in the constant habit of observing the various phenomena which they present, can be met with everywhere in this prairie country, fully answer the suggestions contained in the full extract which I have made. Arboreal seeds when thrown upon the unbroken prairie do germinate and grow to trees, but with difficulty, no doubt, on account of the sward on which they fall, and the great danger to which they are exposed, especially from fires. Where they have no protection from these their destruction is almost certain, no matter how readily

the seed may germinate or how vigorously the young plants may grow. It does not require the cultivation of the soil, the mixing of the clayey subsoil with the black mould of the surface, to insure the successful growth of trees upon the prairies. Indeed, I have already shown that not all the prairies have a clayey subsoil, and, as is elsewhere shown in the paper under consideration, in but few instances does the clay approach the surface to within the reach of the plow. The whole theory under consideration is based on the fatal error that the prairie soils are not adapted to the growth of trees. I do not speak from mere conjecture, but from carefully observed and well attested facts, when I say that the exact reverse is the case.

We have, then, obvious reasons why the scattered clusters of trees referred to, the isolated groves upon the prairies, have not extended their domain so as to embrace the whole field. The prairie fires, the matted, tough sward, the grazing of wild animals in the neighborhood of the groves to which they resorted, the aboriginal encampments usually located around the borders of the groves, would seem to present a sufficient explanation why the groves have not extended, independently of the quality of the soil. That the cultivation of the prairie soils improves their condition for the growth of trees is proved by the more vigorous growth of those where the ground is cultivated than those which spring from seeds accidentally scattered on the prairie along the borders of the groves; but this is true of herbaceous vegetation as well.

Who that is intimately acquainted with and has carefully studied the prairies will dispute that the soil of the groves has been formed by the same process that has formed the soil of the treeless prairies? The theory that these groves mark out the places where the agitated waters have thrown up embankments, which cut off the shallow

waters where the naked prairies have been formed, is not sustained by either the topography or the geography of the ground. If this theory were true we should find the groves in continuous lines, upon elevated ridges, composed of sand and gravel, such as we uniformly find to comprise those dykes, which, undoubtedly, have been formed as supposed, and have performed the office assigned them. Such, however, is not the case. In very few instances do we find the groves occupying continuous, unbroken ridges of any considerable extent. We find them scattered over the prairies, without law or order, excepting only the condition of water in some form in their vicinity, which may serve to protect them from the conflagrations of the prairies. This water need not charge the soil itself with humidity in order to secure the growth of trees, for it is not uncommon to find the groves occupying the highest and driest knolls, but at their feet, or at least so near as to serve as a protection, water is sure to be found. In former times, when the traveler, in crossing the great, wild prairies, saw a grove in the distance, he shaped his course to it, with the absolute certainty of finding water there, no matter how dry or parched the prairie might be.

The soil, too, gives no evidence of an accumulation of material, such as is usually thrown up by agitated waters. When we penetrate the soil of the woodlands, even to great depths, as in digging wells, and the like, we find the same formations which are met with in the surrounding prairies. I have already alluded to the fact that whenever we find a chain of groves occupying the high divides of the water sheds of the prairies, they are generally separated by deep depressions, which would have destroyed them as dykes for the separation of the waters.

As I have already stated, I am prepared to admit, as almost a demonstrated fact, that not only our great prai-

ries, but also our great forest lands and the desert plains, filling all the space between the Alleghenies and the Rocky Mountains, were originally formed or deposited under water, from which they have emerged by some process of nature, probably very slow; but this elevation has not been dependent, to any considerable degree, upon additional deposits, but upon the actual upheaval of the mass of matter originally submerged, or the subsidence of the waters by the removal of barriers which once restrained them. And yet, if all prairies have been formed as supposed by the theory which I have taken the liberty of criticising, they have been formed by deposits in the water till, by successive accumulations, they have finally emerged above the waters.

To me the evidence that this is not so is absolutely conclusive, as well as that the deposits have been very insignificant, since they were deeply buried under the waters. I will state some of the facts, within the observation of all men, which have led me to this conclusion.

I think it is universally accepted, at least among scientific men, that the rocks (called boulders) scattered over most of our prairies, at least east of the Missouri river and north of latitude forty, have been transported from their original beds in the north to their present places by means of floating ice. Apart from the admitted fact that this is not their native place, or *that they did not grow here*, and hence must have been transported by some agency, and of our absolute inability to conceive of any other capable of producing such results, many of the masses, especially in the Iowa prairies, weighing hundreds of tons each, and the additional fact that their rounded form has been acquired by abrasion, by which their sharp angles have been worn away since they were detached from their original beds, and we can conceive of no other adequate

agency to produce this result but moving water and ice,— I say, aside from all this evidence, within two miles of where I now write, the most convincing evidence exists that these boulders were brought by icebergs. To the north, but more especially to the west, of the city of Ottawa, and almost within its limits, it is easy to trace the exact size and form of the masses of ice, where they grounded and deposited their freight of boulders. There one may walk over a quarter of an acre, a half an acre, or several acres, according to the size of the mass, always stepping on these stones, thus deposited close together as they were when embraced by the congealing waters, and outside of the borders not a single stone can be found till another similar collection is met with. The borders of these collections are as sharply defined as if marked with a wall. Here, too, another interesting fact may be observed, which shows that they were not transported in one voyage from their original homes to their present resting place. We observe a single collection composed of a great variety of rocks—several kinds of granite, trap gneiss, sienite, and perhaps a dozen others, which we know, from their far distant beds, had been drifted or rolled together from long distances, and worn to their present form, before they were picked up for their last voyage.

The rock-bound shores of Lake Superior show us how these boulders were formed. There, in many places, we may see before us the lately detached blocks of rock, with all their angles sharp, and, as we pass down from the top of the cliff over the broken masses to the very edge of the water, and even look beneath it, we find the angles of the blocks more and more worn, and the masses themselves smaller, till at last, when we reach the water and look into it, we see before us the smooth, rounded bould-

ers, as we see them on our prairies; and if we will stand there when a heavy sea is rolling in, we shall see the great blocks of stone jostled together and the process of abrasion going on before our eyes. It may take a thousand great storms to wear away an ounce from a single block, yet enough millions of such storms will at last do the work, and that effectually. Perhaps the most accessible point where this manufacturing of boulders can be witnessed is on the mainland west of Partridge Island, a few miles above Marquette. I cannot forbear to mention one other interesting evidence of the transportation of these prairie boulders. A few miles south of Waterloo, in Black Hawk county, Iowa, is the fragment of an immense boulder, which must weigh many hundred tons, showing on one side a distinct face of a comparatively recent fracture, and I was credibly informed that many miles distant a similar fragment existed, with a face the counterpart of this, showing that at one time both had constituted one mass.

Now, assuming that our prairie boulders were transported by icebergs to their present places, and that we are, in some cases at least, enabled to determine the minimum sizes of the bergs which brought them, we are forced to the conclusion that the prairies were covered by deep waters at the time of their transportation. We may safely assume that ancient bergs resembled those now seen floating from the frigid zones into lower latitudes, where they often ground and are melted away, depositing whatever heavy material they have brought with them from their starting point, which we are told by arctic navigators is always at or near the shore. If this be so, we know they must have required a great depth of water to float them. Bergs are now frequently met with projecting hundreds of feet above the water; and, as they float with

at least five-sixths of the mass under the water, we may form an approximate idea of the depth of the water here when these boulders were deposited. At least, we may assume that it was very considerable. Had there been any considerable deposit after these boulders were dropped where we now see them, while they were being elevated above the waters, they must have been deeply buried beneath this deposit, and we should not have this clear evidence, at least, of the former submergence and of the very insignificant deposition during the process of elevation from beneath the waters.

I claim no originality in these suggestions. I have only stated what I believe to be the accepted theory by the most observing and reflecting men in accounting for the presence of the prairie boulders; but what I claim is, that the patent facts stated are inconsistent with the theory that the great body of our prairies have been built up by accumulations and deposits in shallow water till they were raised above it, and then finally till they have attained their present altitudes. I say the boulders alone absolutely forbid this, unless they, too, were deposited in very shallow water, or in most cases long after the emergence. But few facts have ever been established by circumstantial evidence more conclusively than this.

But even admitting the shallow pond theory as fully established, and clearly showing how all the soil of the prairies has been formed, and it by no means affords as satisfactory a solution of the problem presented by the absence of trees upon the prairies as I have attempted to show in a previous portion of this paper.

Indeed, we venture upon very much whenever we assume to explain all the laws by which nature works out her great results, or to state all the causes which may have tended to produce this one result. One cause or set of

causes, if I may use the expression, may have produced it in one place, and another may have produced it in another place. While we may have clear proofs of the existence and operation of some of these causes, we may not deny that others, and many of them, have been operating for ages on ages since the prairies became dry land, first to promote the growth of one kind of vegetation which by other causes has been destroyed and replaced by another, and, for aught we know, this process may have been many times repeated. In contemplating these works of nature we are too apt to confine our reflections to yesterday. When we pause, and let the mind run back through the vista of time till it becomes bewildered and lost in the contemplation of distance without end, we are then prepared, when we return to complete consciousness, to appreciate that the growth of the oldest tree of the forest, when considered in relation to past time, has been as rapid as is that of the eastern magician, who plants the seed of the orange before your eyes, and while you yet look the tender plant springs from the ground and grows up to a full sized tree, bears blossoms, which fade and fall, and the green fruit appears in their places, which immediately grows to its full size, matures and ripens, and you are invited to pluck and eat, and you find in your hands a veritable orange, rich, juicy and nourishing. I say this is but the history of our oldest forest trees, when contemplated with reference to the ages that must have elapsed since this land emerged from the bosom of the waters. During all these rolling years surely there has been time enough for the prairies to have been clothed with forests, and again denuded of their trees, and for the process to have been many times repeated, by agencies not beyond our comprehension or nature's laws. But because this may have been, I have no warrant for saying

that it has been, for the want of tangible proof of the fact. I may even assert its probability, or my belief that it has been so, but at last it is but conjecture, and as such alone may be suggested. Still we cannot shut our eyes to the fact that the study of the geology of this country, in some of its departments at least, is yet in its earliest infancy. May we not reasonably hope that its maturity will develop facts which will dispel the obscurity which now veils many subjects of most interesting inquiry, and enable us to read the past in a clear and convincing light? For instance, the prairies abound in beds of peat, of greater or less extent, some of vast proportions. As yet these are comparatively sealed volumes of history, which, when they shall be opened and read, as they have been in what we call the older countries of the world, will reveal the record of bygone ages. What treasures of truths have been revealed by the examinations of the peat-beds of Denmark, to which reference may be made as quite appropriate to the present inquiry! These are of depths varying only from ten to thirty feet, formed like ours, in basins in the drift. They tell us, as plainly as if written in a book, of the different successive forests which there have lived and flourished, and finally disappeared, and been succeeded by others. The oldest which they reveal is the Scotch Fir, (*pinus sylvestris*,) which is not now found in Denmark, and cannot even be domesticated there. Then succeed several varieties of the oak, one after the other, and so on, until finally at the last the beech is found, which is still the common forest tree of Denmark, and so it was two thousand years ago, as we learn from written history. How admirably do we here find united into a long chain of history the various links which we see deposited in these beds of peat, the last of which, being united with and interpreted by written histo-

ry, enable us to read all the rest, with almost as much confidence as if the written history extended back to the time when the first layer of peat was deposited. How shall we restrain our impatience till the seal shall be broken to similar volumes of history, which lie profusely scattered all over prairie land, waiting to be opened and read by the discriminating geologist? There we may reasonably hope to find facts which will throw a flood of light on the subject of our present inquiry. There alone may we hope to learn, with a reasonable degree of certainty, what kinds of vegetation have grown on these great plains in the long gone ages of the far distant past.

But the supposition of igneous agency in producing the effect under consideration is not a mere speculation or conjecture. It is an established fact, proved by such evidence as leaves no room for controversy. So that whatever else may also have contributed to the same result, fire at least has done its share. In almost every year, in some part of the country, whole forests are consumed by fire. In a majority of instances, no doubt, a new growth of trees takes the place of the old, but such is not always the case. Mr. Daniel Ebersol, of this city, who is a good observer, and of undoubted veracity, informs me that many years ago, on the Vermilion River, a fire occurred, under his own observation, which utterly destroyed, root and branch, an entire hard-wood forest, and that the entire burnt district was directly taken possession of by the herbaceous plants peculiar to the prairies, and that in a very few years it could not be distinguished from the adjoining prairie, except by its greater luxuriance. The testimony of Mr. J. E. Shaw, who has resided upon the prairies of Illinois for more than fifty, and upon his farm, within two miles of Ottawa, for more than forty years, is equally to the point. He assures me that he has known

many forest districts entirely burned over and every living thing upon them destroyed. Generally they were replaced with trees similar to the former growth; but that sometimes the prairie herbage takes and maintains possession. He cites an instance on his own farm, where, forty years ago, when he took possession, there was a forest of large trees, which was destroyed by a fire, when a part of the burned district was again covered with trees, and a part was taken possession of by the prairie grass, and in a comparatively short time could not be distinguished from the adjoining prairie. He mentions another occurrence of the same kind within his own observation, in Putnam county. All who know Mr. Shaw, as I have for a third of a century, will place implicit confidence in the truth of his statements and the accuracy of his observations. Indeed, the character of the latter is such as scarcely to admit of mistake. But corroborating testimony is abundant. I have conversed with many old settlers in different parts of the prairie regions, who mention similar occurrences. I venture the assertion, that a thousand witnesses may be found still living who can state particular instances of the same kind. In my early wanderings over the wild prairies it several times occurred, when approaching a body of timber, that I met in the prairie grass charred remains of forest trees, perhaps half a mile or more from the edge of the wood, and I have in no instance inquired of one who had similar facilities for observation who did not remember having observed the same thing.

In a former part of this paper I have shown, by evidence which may be seen and comprehended at this day by every observer, how prairies have been and are still being converted into forests. I have now stated, with considerable particularity, evidence satisfactorily showing

how forests have been converted into prairies. This seems to me of the very essence of the inquiry, which can alone be solved by evidence of authenticated facts, one ounce of which should be entitled to more weight than a pound of ingenious conjecture.

How vain, then, are the most plausible theories and fine spun speculations, when we have this palpable, tangible proof of the actual process by which the result has been produced, and that by a simple cause adequate to the result. If the thousand witnesses who have observed this process going on before their very eyes had been in the habit of writing and publishing their observations for the last half century, the question would have been long since so conclusively settled, both among the learned and the unlearned, that all men would be surprised that it was ever a subject of dispute. The great danger to truth would have been that too much effect would have been attributed to igneous agency. For myself, while I am prepared to believe that this has been the most potent of all the causes contributing to the result, I am also prepared to admit that there have been many minor auxiliary causes aiding the principal one, which may have escaped the attention of observers. Least of all of these are the facts, which may be considered established as such, and which tend to support what may be termed the shallow pond theory. Those which are invoked in support of what may be termed the arid theory may have had a considerable influence in aid of the prairie fires on what may be termed the fertile prairie, and even the most controlling cause on the desert plains, where both herbs and trees are nearly wanting for the lack of moisture to sustain them, even if once there planted. Where there is not sufficient rain fall to sustain trees when planted, we may reasonably assume that that is the cause of their absence; but I am slow,

to believe that this, or the peculiar constituents of the soil, is the principal cause where trees grow and flourish vigorously when once introduced. The same cause which keeps them away should kill them when present, if still operating. If there is less annual rain fall in prairie than in timber districts, we may appreciate that fires, from that cause, may have been more frequent and more destructive, while our daily observation proves that the limited quantity of rains does not render the soil or the atmosphere unadapted to the growth of trees, at least on the prairies east of the Missouri River.

In grouping together some of the facts in support of what may be denominated the igneous theory, I but state a theory which is as old as the first white settlements upon the prairies; but because it has been universally accepted by those who have had the greatest opportunities for observing the facts bearing upon the question, although they make no pretensions to scientific attainments,—for that reason I do not feel called upon to reject it, and with it a great volume of facts which seem to conclusively establish it. At least till some one else shall produce other tangible facts, as well supported by proof as these, in support of some other theory, and tending to prove the fallacy of the conclusions deduced from these, I must believe that the popular opinion of the country is in the main correct.

Perhaps I have too little respect for mere theories, and too much reverence for facts. I cannot be content with general observations of facts without descending to their minute details, which in my view become of immense importance as qualifying or explaining more general observation. If, without the careful study of well established facts, mere theories may be draped in the tinsel glitter of learned speculations, they can never satisfy that whole-

some craving for exact knowledge, which alone forms a sure basis for definite conclusions. Science has sometimes suffered grievous wrong from some of her votaries, who have felt called upon to explain everything, whether explicable or not by ascertained facts; and, indeed, the more occult the explanation, the more profound would their learning appear. If it so happen that manifest facts are opposed to their theories, why—so much the worse for the facts!

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